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GB 1064941 A GB 1042179 A EP 0152181 A2
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(54) Inspection systems for vehicles using line scan camera and reflector

(57) An inspection system, for inspecting a vehicle's under surface, comprises a light reflector 4 positioned to receive and redirect light images of an object to the lens of a line scan CCD camera 1. In one embodiment the light reflector comprises a prism 4 or a mirror or system of such prisms and/or mirrors and the line scan camera is a single line scan camera 1. A wide angle adapter 2, compact housing 3, window 5 and fluorescent light tubes 6 are shown. The housing may be positioned in a trench, on a road surface or be wheel mounted to be movable beneath a vehicle.

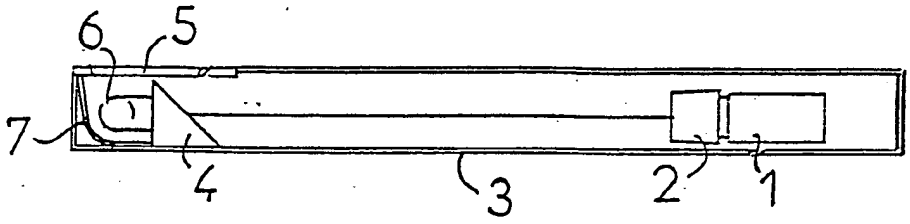

FIG. 1

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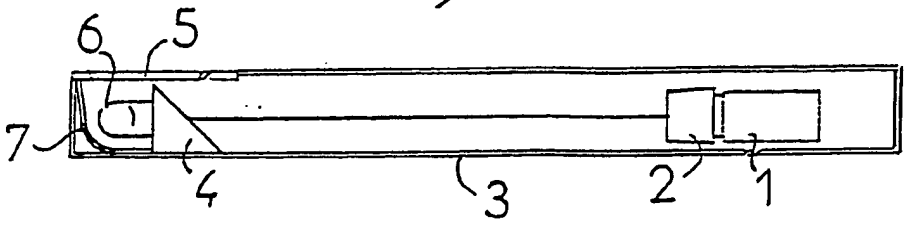

FIG. 1

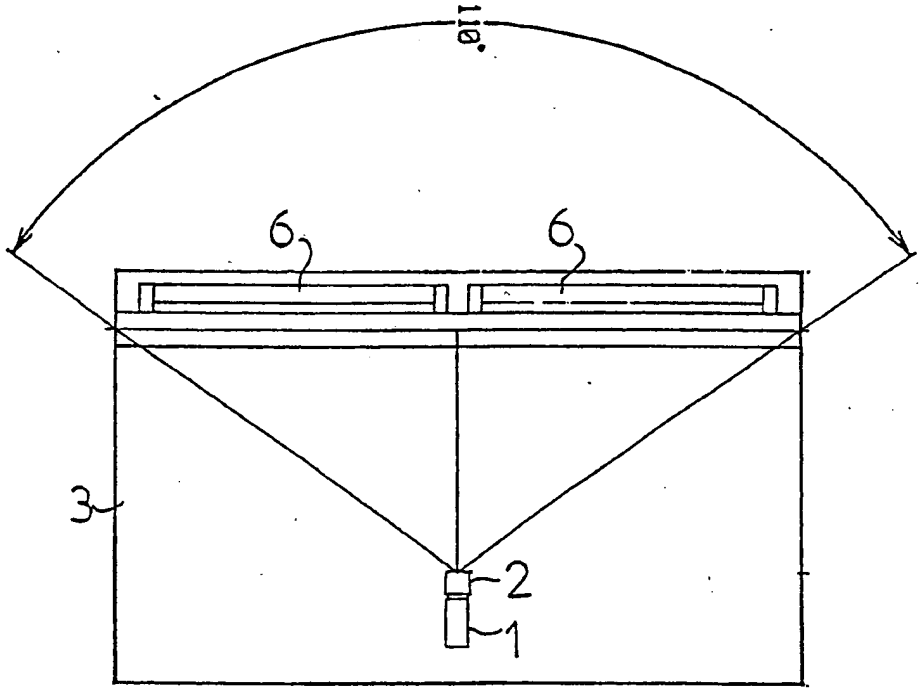

FIG. 2

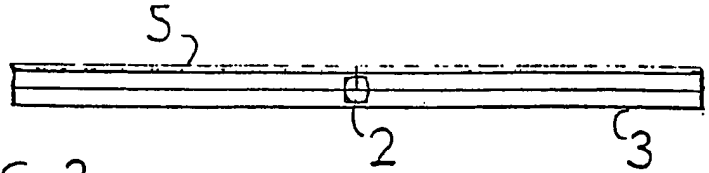

FIG. 3

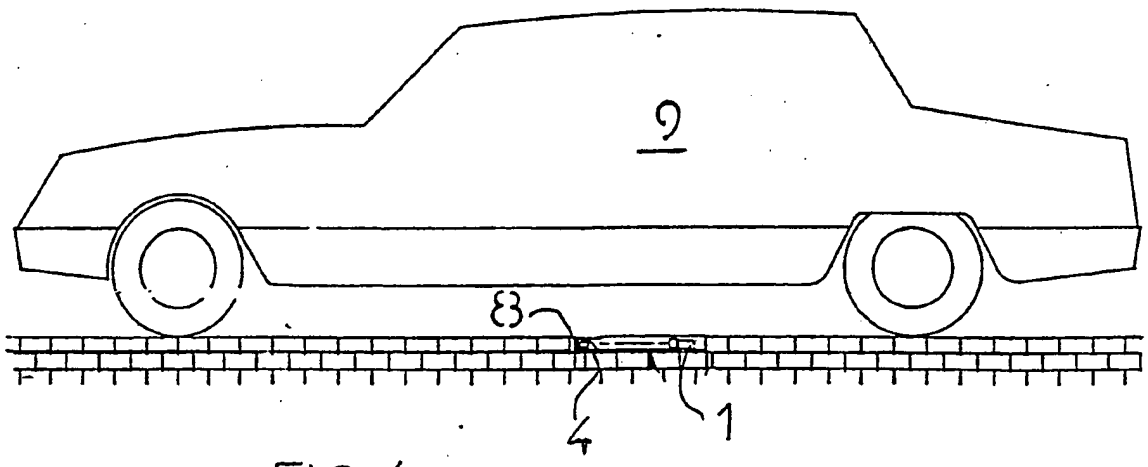

FIG. 4

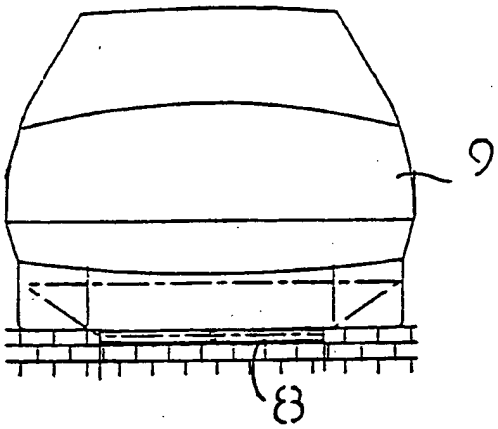

FIG. 5

IMPROVEMENTS IN AND RELATING TO INSPECTION SYSTEMS

This invention relates to inspection systems and more especially to inspection apparatus and methods which provide a representative picture of the underside of a vehicle.

Presently available apparatus for inspecting the underside of vehicles essentially comprises one or more hand held pole mounted mirrors. To identify foreign objects secured to or hidden within the structure of a vehicle's underside, it is necessary for the person conducting the inspection to recognise the presence of objects or shapes from a personal knowledge of the particular vehicle under inspection. At best, such known

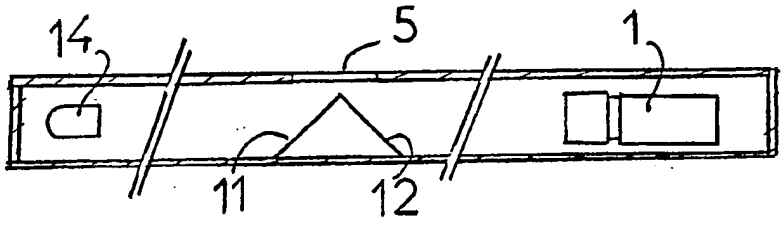

FIG. 6

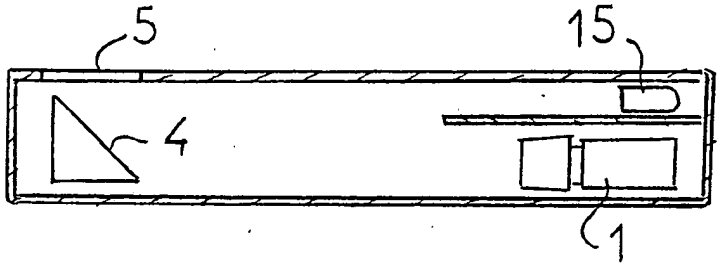

FIG. 7

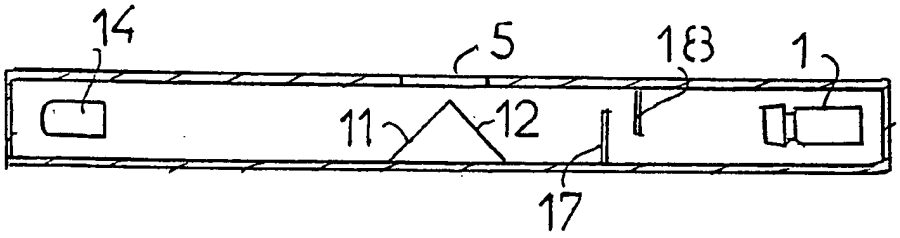

FIG. 8

inspection apparatus will identify only more obvious foreign objects.

One object of the present invention is to provide an inspection system which produces a representative picture of a vehicle's underside for close inspection to identify additions or changes which might indicate the presence of foreign objects.

According to the present invention in one aspect there is provided an inspection system for inspecting the underside of a vehicle, the system comprising a reflector positioned to receive and redirect images of an object to the lens of a line scan camera positioned within a relatively compact housing, the light reflector being located below a window set in an upper wall of the housing at a position removed from the camera.

The light reflector may comprise a prism or a mirror or system of prisms and/or mirrors. In a preferred arrangement, a system of two mirrors each set at a common angle to the vertical and each defining two sides of an imaginary isosceles triangle are employed, one such mirror being positioned to reflect light from a light source through the window of the housing towards the undersurface of a vehicle positioned above the window and the other being positioned to direct light images of the vehicle's undersurface to the line scan camera. By a "line scan camera" is meant a camera in which processable data can be produced from one or a limited number of data lines of the

picture produced . In a preferred embodiment, a single line scan camera is employed, each line comprising 200 to 3000 pixels (typically 1000 pixels) of information; in this preferred embodiment, the system is typically capable of storing in excess of 4000 individual lines.

The light source may comprise for example, fluorescent tubes, one or more point light sources, one or more light emitting diodes or one or more scanning lasers. Other lighting means may, however, be employed. Where appropriate, the light source may comprise a "D" shaped lens. Preferably the depth of the housing is minimised; at best, the housing depth and breadth is just sufficient to house the camera and the light reflector. The length and breadth of the housing are selected to provide the required distance between the camera lens and the object to enable the full object width to be efficiently scanned. In one arrangement, a system of mirrors is employed to reduce the linear distance between the camera lens and the mirror. In use the housing is positioned generally horizontal with the window in its upper wall. The window may simply comprise an opening. Alternatively, the window may comprise toughened glass (preferably of optical quality) or opaque plastic sheeting located in a frame.

The camera and light source may be positioned in the housing on the source or opposite sides of the mirror. In the former case, a shield may be provided to separate the camera lens from the light source. The bands of

wavelength of light source and the camera lens are preferably matched. A narrow angle lens may be employed for enhanced inspection of, for example, the wheel arches of a vehicle.

Two side-by-side line scan cameras may be provided to provide a 3-dimensional image of a vehicle for enhanced inspection potential. Also, the mirror or lens may be suitably inclined to record a licence plate of a vehicle to be inspected.

The housing may be sited within a suitably contoured recess set in a road surface. Alternatively, the housing may be positioned on a road surface and may form a central section of the ramp assembly, be wheel mounted or be carried by a trolley or the like movable over a road surface. Light reflecting side walls to the housing may be provided.

Means may be provided for recording the speed of a moving object, eg. a vehicle, relative to the inspection apparatus, or vice versa. Thus, the speed detection means may be used to record the speed of a vehicle moving over a stationary inspection apparatus or to record the speed of a wheeled apparatus or a trolley mounted inspection apparatus moving under a stationary vehicle. The speed detection means may be electronically linked to the camera, to vary the scanning speed thereof in dependence on the monitored speed.

The light images received by the camera may be compiled to produce a complete picture of the underside of the vehicle under inspection and/or may be transmitted to an electronic processing for subsequent processing when supplied to a high resolution monitor, the image (or a part thereof) may be capable of enlargement for close inspection purposes.

In another aspect, the invention provides apparatus for inspecting the underside of a vehicle, the apparatus comprising a housing including a line scan camera mounted with its lens facing towards a prism or inclined mirror positioned to direct light images from a vehicle positioned above the housing to the camera lens, the height of the housing being reduced to a minimum consistent with the span necessary to house the camera and lens or mirror.

In a further aspect, there is provided a method of inspecting the underside of a vehicle which comprises passing light images of a vehicle's underside to a prism or mirror positioned to redirect the images to the lens of a line scan camera whose optical axis is set on an angle (preferably approximately 90°) to the object under inspection.

The invention will now be described by way of example only with reference to the accompanying diagrammatic drawings in which:-

Figure 1 is a side view of inspection apparatus in accordance with the invention;

Figure 2 is a plan view from above of the apparatus illustrated in Figure 2;

Figure 3 is an end view of the apparatus illustrated in Figures 1 and 2; and

Figures 4 and 5 are respectively side and rear views of apparatus in accordance with the invention set into a road surface; and

Figures 6 to 8 are side views of alternative inspection apparatus in accordance with the invention.

The apparatus illustrated in Figures 1 to 3 comprises a single line scan CCD camera (1) having, for example, a 3mm lens and a wide angle adaptor (2). The camera (1) is positioned within a relatively compact housing (3). Spaced from the camera (1) is an inclined mirror (4).

The mirror (4) is positioned below a heavy duty glass or plastics window (5) set in a frame carried by the upper wall of the housing (3). The mirror may be silvered to increase its reflectivity. The window is illuminated from below by a light source comprising a pair of fluorescent light tubes (6) and a curved reflector (7). The wavelength bands of the camera and the light source are preferably matched. The glass of the window (5) may be of optical quality to enhance image reflection and the window itself may be inclined to the horizontal to prevent reflected light from the light source passing to the

camera lens. Means may be provided to clean the exposed surface of the window, such means possibly comprising a shutter carrying a blade or the like which moves across the exposed surface of the window as a vehicle approaches the apparatus. A degreasing and/or cleansing agent may be carried by the blade as it moves across the window to clean the same.

The dimensions of the housing are selected to reduce to a minimum the height of the housing thereby enabling the housing to be sited in a shallow trench, to be positioned on a road surface whilst enabling a vehicle to pass over it (the apparatus preferably forming a central part of a ramp assembly), to be wheel mounted, or to be carried by a wheeled trolley movable beneath a vehicles underside. Preferably, the height of the housing (3) is simply dictated by the heights of the camera (1) and the mirror (4). Reflective shields may be provided along each side of the camera to increase reflectivity and enhance performance. The length of the housing (3) is selected to provide an adequate distance between the object and the camera lens to enable the required picture to be produced and the width of the housing (3) is selected to give the required scan width. Typically, the housing depth is of the order of 63mm; the housing width is of the order of 1 metre; and the housing (3) length is of the order of 600mm. Means may be provided within the housing to control the temperature and/or humidity extant within the

housing. The housing interior is preferably blackened to minimise light reflection. Typically the window (5) extends across the full width of the housing (3) and it extends rearwardly from the front lip of the housing (3) a distance of approximately 120mm. These dimension are simply given as exemplary of typical dimensions.

The housing (3) may be produced from any material having the required strength characteristics, e.g. steel.

The housing itself may be protected from vibrational shocks caused by vehicles passing over it by any conventional means. Thus, the housing may be positioned below a metal grid or the like and may include damping devices to protect the camera, mirror and other housing components.

Alternative light sources to that described may be employed. Thus one or a linear array of point light sources or light emitting diodes may be employed. The point light sources may be "D" shaped. Alternatively, one or more lasers sequentially scanning the full length of the mirror may be provided, the sequential scanning operation being produced electronically or by, for example, rotating mirrors onto the surface of which the or each laser is directed.

A narrow angled lens camera may be provided to provide enhanced inspection of such areas as the wheel arches of a vehicle. Also, the mirror may be inclined away from 45° to enable the licence plate of the vehicle

to be recorded, this information being stored with recorded details of the vehicle's undersurface for identification purposes.

Two cameras positioned side-by-side (or one above the other) may be provided to produce a 3-dimensional picture of the underside of a vehicle under inspection.

As will be seen from Figures 4 and 5, the housing (3) is located in a channel (8) set in a road surface with the mirror (4) positioned to direct light images of the underside of a vehicle (9) to the lens of the camera (1).

In use, as the vehicle (9) drives over the inspection apparatus, object windows of approximately 1700mm by 2mm are viewed and recorded by the camera, one line at a time. Typically, 4000 lines consisting of over 1000 pixels of information will be stored; this information being processed electronically to produce a picture for inspection.

The information collected is typically stored on a computer capable of providing image enlargement of selected sections of a recorded picture, of texture recognition, of high lighting differences between a recorded picture and a standard picture of that vehicle or type of vehicle, and of fractual image compression.

A simple speed monitor (not shown) is provided to detect the speed of the vehicle (9) and to use this information to control, for example, operation of and pixel rate of the line scan camera. Minor fluctuations in

speed from the point of measurement to the camera may cause the apparent vehicle length to vary; such changes can, however, readily be compensated for.

When no vehicle is approaching the inspection apparatus, the controlling computer (or camera) may enter a light metering mode such that the appropriate lens aperture of the lens is set on when a vehicle approaches.

In the arrangement illustrated in Figure 6, a system of two mirrors (11,12) each inclined at 45° to the vertical is employed, each mirror representing one side of an imaginary isosceles triangle. In this arrangement, a light source (14) is positioned to direct light onto one mirror (11) to illuminate a vehicles underside and the other mirror (12) is positioned to direct light images of the illuminated vehicle underside to the lens of the camera (1). This arrangement enables the light source to be positioned not only away from the camera lens by but also remote from the window (5).

The camera and light source are preferably equi-distance from the mirror.

In the arrangement illustrated in Figure 7, light source (15) is positioned above the camera (2) but separated therefrom by a shield (16).

Finally, in the arrangement illustrated in Figure 8, the light path from the camera is effectively increased by means of spaced generally vertical mirrors (17,18)to reduce the overall length of the housing.

It will be appreciated the foregoing is exemplary of one particular embodiment of inspection apparatus in accordance with the invention and that modifications can readily be made thereto without departing from the true scope of the invention as set out in the Claims appended hereto.

CLAIMS

1. An inspection system for inspecting the underside of a vehicle, the system comprising a reflector positioned to receive and redirect images of a vehicle's underside to the lens of a line scan camera positioned within a relatively compact housing, the light reflector being located below a window set in an upper wall of the housing at a position removed from the camera.

2. A system as claimed in Claim 1 wherein the light reflector comprises a prism or a mirror or a system of such prisms and/or mirrors.

3. A system as claimed in Claim 1 or Claim 2 wherein the light reflector comprises two mirrors each set at a common angle to the vertical and each defining two sides of an imaginery isosceles triangle, one such mirror being positioned to reflect light from a light source positioned within the housing to and through the housing window and the other mirror being positioned to direct the image received through the window to the lens of the camera.

4. A system as claimed in Claim 1 or Claim 2 wherein the line scan camera is a single line scan camera.

5. A system as claimed in Claim 4 wherein each scan line of the camera comprises between 200 to 3000 pixels of information.

6. A system as claimed in any one of Claims 1 to 5 wherein the window comprises toughened glass or opaque plastic sheeting located in a frame.

7. A system as claimed in Claim 6 wherein cleansing means are provided to clean the outer surface of the glass or plastic sheeting.

8. A system as claimed in Claim 7 wherein the cleansing means comprises a shutter including a wiper movable across the outer surface of the glass or plastic sheeting.

9. A system as claimed in any one of Claims 1 to 8 wherein, in use, the housing is sited within a suitably contoured recess set in a road surface.

10. A system as claimed in any one of Claims 1 to 8 wherein the housing is wheel mounted or is carried by a trolley or the like.

11. A system as claimed in any one of Claims 1 to 10 further comprising means for recording the speed of a moving object relative to the inspection apparatus.

12. A system as claimed in Claim 11 wherein the speed detection means is electronically linked to the camera, to vary the scanning speed thereof in dependence on the monitored speed.

13. A system as claimed in any one of the preceding Claims wherein light images received by the camera are compiled to produce a complete picture of the underside of the vehicle under inspection.

14. A system as claimed in Claim 13 wherein the light images are transmitted to an electronic processor for subsequent processing.

15. A system as claimed in Claim 16 wherein the electronic processor comprises a high resolution monitor.

18. Apparatus for inspecting the underside of a vehicle, the apparatus comprising a housing including a line scan camera mounted with its lens facing towards a prism or inclined mirror positioned to direct light images from a vehicle positioned above the housing to the camera lens, the height of the housing being reduced to a minimum consistent with the span necessary to house the camera and lens or mirror.

17. A method of inspecting the underside of a vehicle which comprises passing light images of the object to a prism or mirror positioned to redirect the images to the lens of a line scan camera whose optical axis is set on an angle to the object under inspection.

18. A method as claimed in Claim 17 wherein the optical axis of the camera is set at an angle approximately to 90° to the object under inspection.

19. Apparatus for inspecting the underside of a vehicle substantially as herein described and as described with reference to Figures 1 to 8 of the accompanying drawings.

20. A method of inspecting the underside of a vehicle substantially as herein described and as described with reference to Figures 1 to 8 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
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Relevant Technical fields

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5 G02B, G03B

(ii) Int Cl (Edition)

Search Examiner
MR C J ROSS

Databases (see over)
(i) UK Patent Office

(ii)

Date of Search
1 OCTOBER 1992

Documents considered relevant following a search in respect of claims 1 TO 20

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2077072 A (H-R) see especially parts 1 and 10	1,16,17 at least
X	GB 2076253 A (NIPPON INTERPHONE)	1 at least
X	GB 1345108 (NIPPON KOKAN) see especially Figures 2 and 3 and parts 2, 22, 23	1, 16 at least
X	GB 1064941 (FAIREY) see especially parts 10, 18, 33 and page 3 line 37 on	1, 16 at least
X	GB 1042179 (C.F.T.H.) see especially Figure 2 and parts 1, 6, 20, 22	1, 16 at least
X	EP 0152181 A2 (MATSUSHITA)	1 at least
X	US 3812505 (UNITEK)	1,16,17 at least

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